Factors Associated with Vaccine Hesitancy Among Adults in Peshawar, Khyber Pakhtunkhwa, Pakistan: A Cross-Sectional Study

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ABSTRACT

Objective: To assess socio-demographic attributes, healthcare workers' encouragement and income status as predictors of vaccine hesitancy among adults in Peshawar, Pakistan.

Methods: The study was a cross-sectional design employing an online survey to obtain data from participants from Peshawar, Pakistan. We used binary logistic regression to ascertain the extent of the association between vaccine hesitancy and independent predictors including age, gender, marital status, education, healthcare worker encouragement, and income level. We set the level of significance at p≤.05.

Results: The study sample consisted of 398 participants with a mean age of approximately 48.05 years. The gender distribution was relatively balanced, with 205 males (51.5%) and 193 females (48.5%). Out of the total participants, 270 individuals (67.8%) accepted the vaccine, while 128 individuals (32.2%) declined it. Males were more likely to be vaccine hesitant than females (OR=2.42,95%CI:1.34-4.38). Healthcare worker encouragement reduced vaccine hesitancy (OR = 0.11, 95% CI: 0.06-0.20). Individuals aged 46-60 showed higher vaccine hesitancy compared to those aged 18-30 (OR = 3.55, 95% CI: 1.44-8.73). Low-income earners were more likely to be vaccine-hesitant than higher-income earners (OR = 5.34, 95% CI: 2.07-13.80). Marital status and education level were not significantly associated with vaccine hesitancy.

Conclusion: This study highlights the complex interplay of factors influencing vaccine hesitancy in Peshawar, Pakistan. Gender, age, income level, and healthcare worker encouragement significantly influence vaccine acceptance. These findings call for targeted interventions to tackle vaccine hesitancy pragmatically and promote vaccine uptake in the Peshawar region of Pakistan.

RÉSUMÉ

Objectif : Évaluer les caractéristiques sociodémographiques, l'encouragement des professionnels de santé et le niveau de revenu comme prédicteurs de l'hésitation vaccinale chez les adultes à Peshawar, au Pakistan.

Méthodes : L'étude était une étude transversale utilisant un sondage en ligne pour obtenir des données auprès de participants de Peshawar, au Pakistan. Nous avons utilisé une régression logistique binaire pour déterminer le degré d'association entre l'hésitation vaccinale et des prédicteurs indépendants, notamment l'âge, le sexe, l'état civil, le niveau d'éducation, l'encouragement des professionnels de santé et le niveau de revenu. Nous avons fixé le niveau de signification à p ≤ 0,05.

Résultats : L'échantillon de l'étude était composé de 398 participants dont l'âge moyen était d'environ 48,05 ans. La répartition par sexe était relativement équilibrée, avec 205 hommes (51,5 %) et 193 femmes (48,5 %). Sur l'ensemble des participants, 270 personnes (67,8 %) ont accepté le vaccin, tandis que 128 personnes (32,2 %) l'ont refusé. Les hommes étaient plus susceptibles d'hésiter à se faire vacciner que les femmes (OR = 2,42, IC à 95 % : 1,34-4,38). Les encouragements des professionnels de santé ont réduit l'hésitation vaccinale (OR = 0,11, IC à 95 % : 0,06-0,20). Les personnes âgées de 46 à 60 ans ont montré une plus grande hésitation vaccinale que celles âgées de 18 à 30 ans (OR = 3,55, IC à 95 % : 1,44-8,73). Les personnes à faibles revenus étaient plus susceptibles d'hésiter à se faire vacciner que celles à revenus élevés (OR = 5,34, IC à 95 % : 2,07-13,80). La situation matrimoniale et le niveau d'éducation n'étaient pas associés de manière significative à l'hésitation vaccinale.

Conclusion : Cette étude met en évidence l'interaction complexe des facteurs influençant l'hésitation vaccinale à Peshawar, au Pakistan. Le sexe, l'âge, le niveau de revenu et les encouragements des professionnels de santé influencent de manière significative l'acceptation de la vaccination. Ces résultats appellent à des interventions ciblées pour lutter de manière pragmatique contre l'hésitation vaccinale et promouvoir la couverture vaccinale dans la région de Peshawar au Pakistan.

INTRODUCTION

Vaccines have been proved elixir for the infectious diseases that previously cost millions of human lives. The unprecedented COVID-19 pandemic further emphasized the utmost significance of vaccines. Vaccines have saved an estimated 154 million lives over the last 50 years and are highly cost-effective, saving US$16 for every dollar spent on healthcare, wages, and productivity losses[1,2]. Despite such pivotal potential to change the health landscape of the country, the world is encountering a new threat that made its way into top 10 threats to global health named as , "vaccine hesitancy" [1]. Vaccine Hesitancy has been referred to as the delay in acceptance or refusal of vaccines despite availability of vaccination services" [2].

In general, Pakistan is believed to have a long history of vaccine hesitancy, rooted in its decades-long national struggle against terrorism [3]. As a result, lingering negative beliefs about vaccines often hinder the population-wide acceptance of vaccination interventions in the country [4]. A recent COVID-19-related study in Pakistan supports this trend, with about half of the respondents exhibiting vaccine hesitancy, largely due to beliefs that the vaccine may cause long-term side effects or even death [5].

Existing empirical research indicates significant demographic disparities in vaccine hesitancy. For example, previous studies indicate that younger adults (18-29 years) consistently show higher vaccine hesitancy rates compared to older age groups [6]. Similarly, gender difference may play a role in vaccine hesitancy, as men are more likely to get a vaccine than women [7]. In previous studies conducted by Ali [8] and Sheikh [5], it was revealed that women tended to be vaccine hesitant due to fear of the vaccine causing infertility. Moreover, educational attainment has a profound impact on vaccination perception, with individuals holding a bachelor's degree or higher demonstrating greater vaccine acceptance [9]. Another important factor is marital status, with married people frequently having greater immunization rates than single people [10]. This trend is particularly pronounced among younger adults and those with lower education levels, who may be more skeptical about vaccine efficacy and safety profile [11,12].

Additionally, income disparities significantly influence hesitancy, with lower-income populations showing greater resistance to vaccination [13]. A study in New Jersey found that household income was one of the strongest predictors of COVID-19 vaccination [14]. Evidence from Pakistan also portends that individuals from low economic classes are more likely to demonstrate vaccine hesitancy [15]. Lastly, healthcare workers play a crucial role in influencing public opinion and confidence regarding vaccines, making their encouragement vital in addressing vaccine hesitancy among the general population. Their recommendations have a substantial positive influence on patients' vaccination decisions [16]. Healthcare workers can employ tailored communication strategies to address individual concerns and misconceptions about vaccines [17]. A study by Opel et al. highlighted that effective communication by health care providers significantly improves parental vaccine acceptance, emphasizing the critical role of provider-patient interactions in public health initiatives [18]. This finding is corroborated by a study on health workers in Pakistan [19].

Given the prevailing issue of vaccine hesitancy in Pakistan, many of the factors identified in previous studies may also resonate in Peshawar, a city that has been at the forefront of polio vaccination efforts. However, historical, cultural, and political challenges have long hindered vaccination efforts in the region. Efforts to promote polio vaccination in Peshawar have often been met with skepticism, exacerbated by incidents of violence [20]. This issue may persist, as evidenced by a recent study on COVID-19 vaccination in various Pakistani cities, including Peshawar, where approximately three-quarters of respondents expressed willingness to vaccinate against COVID-19, but only 17% had registered for vaccination [21]. This raises significant concerns about the ongoing presence of vaccine hesitancy.

Undoubtedly, the success of vaccination interventions requires a comprehensive understanding of the factors associated with vaccine hesitancy, as vaccine intention is context-specific [21,22]. It is therefore imperative to understand the predictors of vaccine hesitancy in Peshawar to inform culturally tailored interventions aimed at improving vaccine acceptance for vaccine-preventable diseases in the region. We hypothesize that certain socio-demographic factors, economic factors, and subjective norms (e.g., healthcare worker influence) will be significantly associated with vaccine hesitancy among the adult population in Peshawar, Pakistan.

METHODS

Study Design and Sample Estimation

This study utilized a cross-sectional survey to assess vaccine hesitancy in Peshawar, Pakistan. We used the Yamane formula for finite populations to estimate the sample size, considering the total population of Peshawar, as reported in the 2023 census, which is 4,267,198. [23]:

$$n = N / (1 + N * e^2)$$

Where:

- n = sample size
- N = population size (4,267,198)
- e = margin of error (commonly set at 0.05)

Substituting the values:

$n = 4,267,198 / (1 + 4,267,198 * 0.05^2) = 398$

We recruited approximately 398 respondents based on this formula. Data collection continued until the desired sample size was achieved. This ensured a sufficient and diverse sample to reflect the socio-cultural and demographic dynamics of Peshawar.

Study Setting

Peshawar, the capital of Khyber Pakhtunkhwa Province, with a population of 4.2 million has been selected for its distinct demographic profiling. People from different parts of the province, Khyber Pakhtunkhwa, come together in Peshawar, and it is thus a melting pot of various socio-cultural dynamics that influence health behaviors, attitudes, and perception and therefore the population is representative of the region's (Khyber Pakhtunkhwa) attitude toward vaccination. Peshawar has been the epicenter of polio vaccination efforts, but it still faces resistance to vaccination for historical, cultural, and political reasons. The efforts to promote vaccinations against Polio vaccination in Peshawar have often been met with skepticism, exacerbated by incidents of violence [24].

Data Collection

Data was collected using an online survey distributed through social media, WhatsApp groups, and emails. A combination of convenience and snowballing sampling techniques was employed. Respondents were encouraged to share the survey link with their personal and social networks after completing the survey, until the desired sample size was ascertained. The demographic variables collected included age, gender, marital status, education level coupled with health care worker encouragement and income level disparity.

Vaccine Hesitancy Measurement

Vaccine hesitancy was measured as the primary dependent variable. Respondents were asked a direct question regarding their vaccination status and attitudes towards vaccines. The question used to measure vaccine hesitancy was:

- "Have you ever hesitated or refused to take a vaccine despite the availability of vaccination services?" (Yes/No)

Variables

Independent Variables:

- Age (continuous, grouped into categories: 18-30, 31-45, 46-60, 60+)
- Gender (Male/Female)
- Marital Status (Single/Married/Divorced/Widowed)
- Education (Less than High School/High School/College/Postgraduate)
- Healthcare Encouragement (Yes/No)
- Income Level (Lower/Middle/Higher)

Dependent Variable:

- Vaccine Hesitancy (Yes/No)

Statistical Analysis

The data were analyzed using logistic regression to identify the independent predictors of vaccine hesitancy. However, prior to logistic regression, chi-square tests of independence were used to explore relationships between categorical variables such as gender, education level, and trust in healthcare providers. Since the likelihood of type I error increases with increasing number of variables, Bonferroni correction was therefore applied to adjust the alpha level.

Adjusted alpha=α/n

Where:

- α is the original significance level (0.05),
- n is the number of comparisons (6 in our case).

By dividing the original alpha level (0.05) by the number of comparisons, the adjusted alpha was calculated as 0.0083. This more stringent threshold of 0.0083 was used to control the risk of Type I errors. The analyses were performed using Jamovi project (2022) which is free, open access robust tools for statistical analysis [25].

Ethical Considerations

Ethical approval for this study was obtained from the Peshawar District Health Office's ethical review board with reference No: PDH/2024/09. The research was conducted

through an online survey with voluntary participation. Participants were fully informed about the study's purpose, assured of their right to withdraw at any time, and no sensitive personal information was collected to ensure confidentiality and ethical compliance.

Logistic Regression Model Equation

The logistic regression model for vaccine hesitancy with the variables Age, Gender, Marital status, Education, Healthcare_Encouragement and Income level is given by:

$$\log (p / (1 - p)) = \beta 0 + \beta 1 * \text{Age} + \beta 2 * \text{Gender} + \beta 3 * \text{Marital status} + \beta 4 * \text{Education} + \beta 5 * \text{Healthcare\_Encouragment} + \beta 6 * \text{Income Level}$$

Where:

- p is the probability of being vaccine hesitant.
- Log (p / (1 – p)) is the log odds of the probability of being vaccine hesitant.
- β0 is the intercept of the model.
- β1, β2, β3, β4, β5 and β6 are the coefficients for the six independent variables.

Before fitting the logistic regression model to examine vaccine hesitancy based on data from a cross-sectional survey, we will first verify several key hypotheses to ensure the validity and reliability of our model. These hypotheses, specific to logistic regression, include:

Absence of Multicollinearity: Regression coefficient values may significantly shift because of multicollinearity, rendering our result untrustworthy and unreliable. Therefore, to detect multicollinearity, we will examine the Tolerance and Variance Inflation Factor (VIF). High VIF values (typically greater than 05) indicate problematic multicollinearity, which requires addressing before proceeding with the model fitting. Moreover, value of tolerance close to value of 1 is in acceptable range.

Presence of outliers: To identify influential data points in our survey data, we will examine Cook's distance values. A Cook's distance exceeding the value of 1 indicates that a particular data point is highly influential and could disproportionately affect the model's estimates. The Cook's distance values are always less than 1 guarantees the absence of outliers.

To measure the goodness of fit of our logistic regression, we will use McFadden's R^2.

RESULTS

The demographic characteristics of the participants is delineated in **Table 1**. The majority were aged 31–45 years (35.7%) and 46–60 years (41.5%), with 22.8% aged over 60. The gender distribution was relatively balanced, with 205 males (51.5%) and 193 females (48.5%). Most respondents were married (69.8%), and 30.2% were single. Regarding education, 44.7% had college-level education, 29.1% had less than high school education, and 26.2% completed high school. Among the 330 respondents who

Table 1. Demographic Characteristics of Survey Respondents

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group	31–45 years	142	35.7
	46–60 years	165	41.5
	Over 60 years	91	22.8
Gender	Male	245	61.6
	Female	153	38.4
Marital Status	Married	278	69.8
	Single	120	30.2
Education	College-level	178	44.7
	Less than High School	116	29.1
	High School or Equivalent	104	26.2
Income Level	Higher Income	205	62.1
	Low Income	125	37.9
Healthcare Encouragement	Yes	245	61.6
	No	153	38.4
Vaccine Hesitancy	Accepted	270	68
	Declined	128	32

provided income data, 62.1% reported higher income levels, while 37.9% had low income. Healthcare encouragement was viewed as an influential factor by participants, with 61.6% believing it could positively impact their vaccine hesitancy, while 38.4% did not share this opinion. Vaccine acceptance was seen in 68% of respondents, while 32% exhibited hesitancy or refusal.

Before undertaking our logistic regression analysis, we verified the absence of multicollinearity and outliers, as these can significantly affect the validity and interpretability of our model. As shown in **Table 2**, all variables have VIF and tolerance values close to 1, suggesting that multicollinearity is not a concern in our model.

The mean and median Cook's distance values as shown in **Table 3** are both 0.00, with a maximum value of 0.05. These values are well below the threshold of 1, indicating that there are no influential outliers in our dataset.

The ROC curve (**Figure 1**) provides a graphical representation of the trade-off between the model's sensitivity (true positive rate) and specificity (true negative rate) across various decision thresholds for vaccine hesitancy. The AUC value of 0.86 reflects the overall discriminatory power of the model. This performance far exceeds the baseline of random guessing (AUC = 0.5).

The overall model fit statistics as depicted in **Table 4** demonstrate that the model adequately explains the variance in vaccine hesitancy. Our model deviance is 293.60,

Table 2. Collinearity Statistics

	VIF	Tolerance
Gender	1.04	0.96
Marital_Status	1.03	0.97
Education	1.02	0.98
Healthcare_Encouragement	1.10	0.91
Age_Group	1.02	0.98
Income level	1.02	0.98

Table 3. Descriptives for Cook's Distance

	Cook's distance
N	330
Missing	68
Mean	0.00
Median	0.00
Standard deviation	0.01
Minimum	0.00
Maximum	0.05

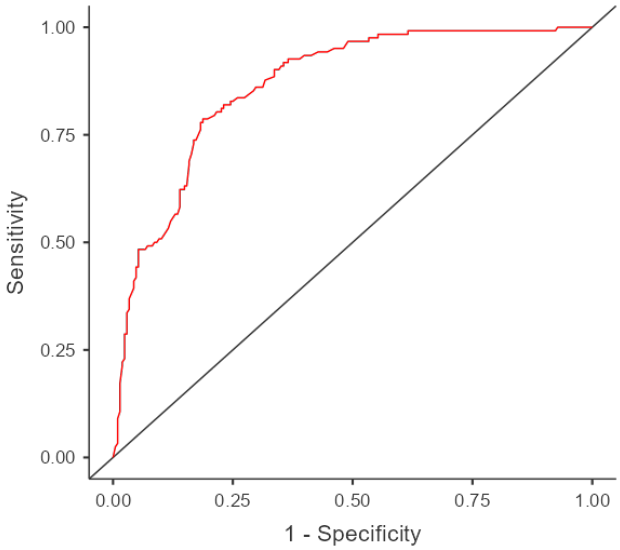

Figure 1. ROC Curve showing the trade-off between the model's sensitivity (true positive rate) and specificity (true negative rate) across various decision thresholds for vaccine hesitancy

with an Akaike Information Criterion (AIC) of 321.60 and a Bayesian Information Criterion (BIC) of 374.79 indicates the goodness of fit of predictive model. McFadden's R^2 value is 0.32 (> 0.2 is considered as safe), indicating that approximately 32% of the variance in vaccine hesitancy is explained by the predictors included in the model. The chi-square test is highly significant ($\chi^2 = 141.20$, df = 13, $p < .001$), further underscores that the model significantly predicts vaccine hesitancy.

Before running the logistic regression, Chi-Square tests were run to examine the associations between vaccine hesitancy and several variables as depicted in **Table 5**. Gender ($\chi^2 = 10.47$, $p < .001$), healthcare worker encouragement ($\chi^2 = 71.30$, $p < .001$), age group ($\chi^2 = 14.59$, $p = .002$), and income level ($\chi^2 = 48.14$, $p < .001$) all showed significant associations with vaccine hesitancy. However, marital status ($\chi^2 = 1.49$, $p = .685$) and education level ($\chi^2 = 8.17$, $p = .043$) were not significantly related to vaccine hesitancy. These results suggest that factors such as gender, education, healthcare encouragement, age, and income are important predictors of vaccine hesitancy, which will be further explored in the logistic regression analysis.

The analysis revealed several significant predictors of vaccine hesitancy as can be seen from the **Table 6**. Gender emerged as a significant factor, with males exhibiting high-

Table 4. Model Fit Measures

					Overall Model Test		
Model	**Deviance**	**AIC**	**BIC**	**R^2_{McF}**	**χ^2**	**df**	**p**
1	293.60	321.60	374.79	0.32	141.20	13	<.001

Table 5. Chi-Square Test Results

Variable	χ^2	df	P	N
Gender	10.47	1	**<.001**	398
Marital Status	1.49	3	.685	398
Education	8.17	3	.043	398
HCW_Encouragement	71.30	1	**<.001**	398
Age Group	14.59	3	**.002**	398
Income Level	48.14	2	**<.001**	330

Table 6. Model Coefficients - Vaccine Hesitancy

						95% Confidence Interval	
Predictor	**Estimate**	**SE**	**Z**	**p**	**Odds ratio**	**Lower**	**Upper**
Intercept	-2.29	0.83	-2.74	**0.006**	0.10	0.02	0.52
Gender:							
Male – Female	0.88	0.30	2.91	**0.004**	2.42	1.34	4.38
Marital_Status:							
Married – Divorced	0.58	0.53	1.09	0.275	1.79	0.63	5.10
Single – Divorced	0.07	0.56	0.12	0.905	1.07	0.35	3.23
Widowed – Divorced	-0.23	0.67	-0.34	0.731	0.79	0.21	2.97
Education:							
High School – College	0.55	0.41	1.33	0.184	1.73	0.77	3.87
Less than High School – College	0.66	0.43	1.52	0.129	1.93	0.83	4.52
Postgraduate – College	0.14	0.62	0.23	0.815	1.15	0.34	3.87
Healthcare_Encouragement:							
Yes – No	-2.23	0.32	-7.01	**< .001**	0.11	0.06	0.20
Age_Group:							
31-45 – 18-30	-0.15	0.48	-0.31	0.758	0.86	0.34	2.21
46-60 – 18-30	1.27	0.46	2.76	**0.006**	3.55	1.44	8.73
60+ – 18-30	0.68	0.44	1.55	0.121	1.97	0.84	4.65
Income level:							
Low Income – Higher Income	1.68	0.48	3.46	**< .001**	5.34	2.07	13.80
middle income – Higher Income	-1.80	0.89	-2.01	**0.044**	0.17	0.03	0.95

Note. Estimates represent the log odds of "Vaccine_Hesitancy = Declined" vs. "Vaccine_Hesitancy = Accepted"

er odds of vaccine hesitancy compared to females (Estimate = 0.88, SE = 0.30, p = 0.004). The odds ratio of 2.42 (95% CI: 1.34 to 4.38) indicates that males are more than twice as likely to be vaccine hesitant as females.

Our findings also indicate that marital status is not a significant predictor of vaccine hesitancy. Specifically, the odds of vaccine hesitancy for married versus divorced individuals (OR = 1.79, 95% CI: 0.63–5.10, p = 0.275), single versus divorced individuals (OR = 1.07, 95% CI: 0.35–3.23, p = 0.905), and widowed versus divorced individuals (OR = 0.79, 95% CI: 0.21–2.97, p = 0.731) were all insignificant. Furthermore, education level does not significantly influence vaccine hesitancy, with all comparisons among education groups yielding non-significant results. For instance, the odds ratios for high school versus college (OR = 1.73, 95% CI: 0.77–3.87, p = 0.184) and less than high school versus college (OR = 1.93, 95% CI: 0.83–4.52, p = 0.129) suggest no substantial differences.

However, healthcare encouragement had a profound effect on vaccine hesitancy. Individuals who received healthcare encouragement were significantly less likely to be vaccine-hesitant compared to those who did not (Estimate = -2.23, SE = 0.32, p < .001). The odds ratio of 0.11 (95% CI: 0.06 to 0.20) indicates a substantial decrease in vaccine hesitancy among those encouraged by healthcare providers.

Similarly, age is also associated with the vaccine hesitancy. Our study indicates that individuals aged 46-60 were significantly more likely to be vaccine-hesitant compared to those aged 18-30 (Estimate = 1.27, SE = 0.46, p = 0.006, OR = 3.55, 95% CI: 1.44 to 8.73). There were no significant differences between other age groups.

Lastly, income level showed significant effects on vaccine hesitancy. Specifically, low-income individuals were significantly more likely to be vaccine-hesitant compared to higher-income individuals (Estimate = 1.68, SE = 0.48, p < .001). The odds ratio of 5.34 (95% CI: 2.07 to 13.80) indicates that low-income individuals have substantially higher odds of declining vaccines jab. Conversely, middle-income individuals were less likely to be vaccine-hesitant compared to higher-income individuals (Estimate = -1.80, SE = 0.89, p = 0.044, OR = 0.17, 95% CI: 0.03 to 0.95).

DISCUSSION

This current study offers pertinent insights into the variables influencing vaccine hesitancy among a relatively large sample of the inhabitants of Peshawar, Pakistan. Our findings highlight the value of healthcare professionals' support in lowering vaccine hesitancy and point to significant socioeconomic and demographic components of the issue. These results can be utilized to create targeted public health initiatives to raise vaccination rates in similar sociocultural contexts.

Our findings reveal that gender significantly influences vaccine hesitancy, with males exhibiting over twice the odds of being hesitant compared to females. This is in contrast with prior research where women often display greater health-seeking behaviors and trust in healthcare interventions [26,27]. The unique sociocultural context of Peshawar, where men are often the primary decision-makers in households, may explain this deviation [28]. Therefore, it is important to understand that these dynamics are critical for tailoring gender-sensitive communication strategies to improve vaccine uptake.

Ironically, our analysis indicates that marital status was not significantly associated with vaccine hesitancy. Comparisons among married, single, and widowed individuals, relative to divorced individuals, revealed no meaningful differences in hesitancy levels. This finding is not consistent with previous research suggesting that marital status may influence health behaviors, often due to spousal support or shared decision-making [29]. However, in the context of Peshawar region, Khyber Pakhtunkhwa, cultural and societal factors might diminish the role of marital status as a determinant since male advice takes precedence in the family affairs [30]. Since our study also found that males were more vaccine hesitant, the concept of shared decision-making within families often defaults to the male perspective as the head of the household, further amplifying their influence on vaccination decisions.

Our findings suggest that education level does not significantly influence vaccine hesitancy. These results stand in contrast to several previous studies that have reported significant associations between education level and vaccine attitudes. For instance, a rapid systematic review found that lack of high school education was the strongest predictor of COVID-19 vaccine hesitancy across U.S. counties [31]. Similarly, a study reported that adults with

higher education levels were more likely to get vaccinated and express confidence in vaccine safety and efficacy [32]. A comprehensive study by Solís Arce et al. found that while vaccine acceptance was generally higher among more educated groups worldwide, patterns of vaccine hesitancy varied across countries [32]. Our findings of non-significant differences between education groups are intriguing and may be attributed to specific characteristics of our study population that differ from those in previous research, warranting further investigation.

Individuals who received encouragement from healthcare providers were significantly less likely to be vaccine-hesitant, with an odds ratio of 0.11 (95% CI: 0.06 to 0.20), indicating a substantial decrease in hesitancy compared to those who did not receive such encouragement. When healthcare providers actively encourage vaccination, it can help reduce vaccine hesitancy by providing trusted, evidence-based information and addressing concerns directly. This finding is consistent with previous study that showed that health care provider can influence decision of mother to vaccinate their kids [33].

Age group was found to significantly influence vaccine hesitancy, with individuals aged 46-60 being more likely to be vaccine-hesitant compared to those aged 18-30. The odds ratio of 3.55 (95% CI: 1.44 to 8.73, $p = 0.006$) indicates that individuals in the 46-60 age group were more than three times as likely to express hesitancy. This aligns with previous studies that suggest older adults may have more entrenched beliefs and greater exposure to vaccine-related misinformation [34]. However, no significant differences were found between other age groups, indicating that hesitancy may not increase steadily with age, but rather may be more pronounced in specific cohorts. These findings highlight the need for targeted interventions for middle-aged adults, especially in addressing their concerns and providing tailored information that resonates with their experiences and needs.

The findings regarding the relationship between income level and vaccine hesitancy reveal a complex pattern that warrants careful consideration. Low-income individuals demonstrated significantly higher odds of vaccine hesitancy compared to their higher-income counterparts. This aligns with previous research indicating that lower socioeconomic status is often associated with increased vaccine hesitancy [35,36].

Strengths and Limitations

This study has a few strengths. The sample size of 398 participants guarantees a comprehensive representation of the sociocultural and demographic characteristics of Peshawar. The validity and reliability of the results is increased by using logistic regression analysis in conjunction with thorough consideration of multicollinearity and outliers. Furthermore, the study's statistical rigor is strengthened using the Bonferroni adjustment for multiple comparisons.

The study does, however, have certain shortcomings. Selection bias may have been created by using an online poll that was disseminated via emails, WhatsApp groups, and social media, thereby underrepresenting people with low levels of digital literacy or internet access. Therefore, future studies should consider capturing interviewer-administered supplementary data on vaccine hesitancy by collaborating with community organizations, healthcare providers, and community leaders, among others, to ensure the inclusion of underrepresented eligible population. Similarly, offering incentives could help encourage maximum participation of underrepresented groups in the supplementary data collection.

The study's cross-sectional design makes it impossible to establish a causal link between vaccine reluctance and the factors that were found. Additionally, the results may not be as applicable to other areas with distinct sociocultural contexts due to the study's exclusive emphasis on Peshawar. Response bias may also be introduced by measuring vaccination hesitancy using self-reported data. Despite these limitations, the study provides valuable insights into the complex factors influencing vaccine hesitancy in Peshawar, offering a foundation for future research and targeted public health intervention.

CONCLUSION

This study has highlighted the factors that stand apart with previous global research by taking into consideration the socio-cultural context of Peshawar region in Pakistan. Notably, males in this region exhibited higher vaccine hesitancy compared to females, which contrasts with global research trends, underscoring the need for interventions to be aligned with the unique socio-cultural context of Peshawar. Our study indicates that improving vaccine uptake requires tailored strategies that address socioeco-

nomic gaps, leverage the power of healthcare providers, and concentrate on male-targeted communication. Lastly, qualitative research could also offer deeper understanding of the cultural and contextual factors influencing vaccine hesitancy in this population.

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Conflicts of Interest Disclosure

There are no conflicts of interest to declare.